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REPORT

on

WATER QUALITY

in

UPPER RIDEAU LAKE

1971

RECREATIONAL LAKES PROGRAM

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MINISTRY OF THE ENVIRONMENT

REPORT

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GENERAL TABLE OF CONTENTS

LIST OF FIGURES.....	ii
LIST OF TABLES.....	iii
SUMMARY.....	iv
INTRODUCTION.....	1
AREA DESCRIPTION.....	3
FIELD AND LABORATORY METHODS	
Physical, Chemical and Biological Field Methods.....	8
Physical, Chemical and Biological Laboratory Methods.....	9
Bacteriological Field Methods and Laboratory Methods..	10
Bacteriological Statistical Methods.....	12
DISCUSSION OF RESULTS	
Temperature and Dissolved Oxygen.....	14
pH, Alkalinity and Free Carbon Dioxide.....	16
Conductivity, Chloride, Hardness and Iron.....	16
Kjeldahl Nitrogen and Total Phosphorus.....	17
Chlorophyll <u>a</u>	18
Bacteriology.....	20
TABLES.....	25
EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES.....	27
GLOSSARY.....	33
BIBLIOGRAPHY.....	37

LIST OF FIGURES

Figure 1:	Map of Upper Rideau Lake showing shoreline development and topography as well as chemical and biological sampling stations.....	6
Figure 2:	Dissolved oxygen and temperature profiles for Station 37(a) for July 25, 1971 and (b) September 26, 1971 in Upper Rideau Lake.....	15
Figure 3:	The relationship between chlorophyll <u>a</u> and Secchi disc as determined from the recreational lakes surveyed in 1971 as well as the individual values for Upper Rideau Lake.....	19
Figure 4:	Bacteriological densities in May.....	21
Figure 5:	Bacteriological densities in July.....	22
Figure 6:	Bacteriological densities in September.....	24

LIST OF TABLES

Table 1:	Iron, Hardness, Total Phosphorus, Kjeldahl Nitrogen, Chloride and Conductivity for Upper Rideau Lake, 1971.....	25
Table 2:	Chlorophyll a and Secchi disc values for Stations 36, 37 and 38 on Upper Rideau Lake, 1971.....	26
Table 3:	Summary of Analysis of Variance Grouping of Stations for Total Coliforms per 100 ml.....	28
Table 4:	Summary of Analysis of Variance Grouping of Stations for Fecal Coliforms per 100 ml.....	30
Table 5:	Summary of Analysis of Variance Grouping of Stations for Fecal Streptococcus per 100 ml.....	31

SUMMARY

Upper Rideau Lake lies near the boundary of the Frontenac Axis and the Smiths Falls Limestone Plain. The area is characterized by a flat to rolling terrain, shallow to no soil cover and is generally well drained. The shoreline slopes are covered with a thin layer of loam or sandy loam with most of the north shore being dominated by rock outcrop. In general, the soil cover is less than the 1.5 meters (5 feet) required by the Ministry of the Environment for the installation of standard subsurface septic tank systems.

The lake was surveyed for five days in the spring and summer and for four days in the fall for chemical, biological and bacteriological parameters.

In Upper Rideau Lake a well-defined thermocline or zone of rapid temperature decline was observed between the warm upper waters (epilimnion) and the cool bottom waters (hypolimnion) during July and September. During these periods, extremely low deep-water dissolved oxygen levels and elevated carbon dioxide concentrations resulting from decomposition of organic matter were observed. Dissolved oxygen concentrations in the deeper strata were not sufficient to sustain cold-water species of fish.

The pH, and total alkalinity values and dissolved mineral concentrations indicated a relatively hard water lake. Surface pH values were consistently higher than in the deeper strata while total alkalinity generally varied by less than 3 mg/l.

Algal levels, as reflected by chlorophyll a concentrations, were moderately high during the August sampling and reached nuisance levels during September. Such high algal densities have been known to reduce severely water oriented recreational activities and to diminish the aesthetic quality of the lake.

The concentrations of Kjeldahl nitrogen and total phosphorus were indicative of an enriched lake. There was evidence of nutrients being recycled from the sediments and that these nutrients were responsible, at least in part, for the high chlorophyll concentrations observed during the September survey.

Upper Rideau Lake generally had good bacteriological water quality, well within the Ministry of the Environment recreational use criteria during all three surveys. However, the bacterial concentrations increased greatly after a rainfall especially near Westport and McNally Bay where there were indications of a possible short term health hazard.

In view of the high nutrient concentrations, algal densities and evidence of excessive bacterial inputs near Westport and McNally Bay, every effort should be made to locate and prevent any direct flow or leachate from domestic waste disposal systems or other potential sources of pollution from gaining access to Upper Rideau Lake.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Ministry of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Department of the Environment in December 1971, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subject to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, these wastes must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do

support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Upper Rideau Lake in the summer of 1971. Three surveys were conducted; a spring survey from May 28 to June 1, a mid-summer survey from July 23 to 27 and a fall survey from September 23 to 27 inclusive. These studies included the assessment of bacteriological, physical, chemical and biological conditions of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution program in Ontario.

AREA DESCRIPTION

Geography and Topography

Upper Rideau Lake is located in North Crosby Township, Leeds County, approximately 48 kilometers (30 miles) north of Kingston. The lake has a water surface area of 14 square kilometers (3400 acres), a maximum depth of 22 meters (72 feet) and a mean depth of 8 meters (26 feet).

The lake lies near the boundary of the Frontenac Axis, a narrow neck of Precambrian bedrock which extends from the Canadian Shield through the Thousand Islands area to the Adirondacks of New York State, and the Smith's Falls Limestone Plain which dominates the eastern townships of Ontario. The north shore lies completely in Precambrian type bedrock consisting of granite, syenite and crystalline limestone with the latter occupying the eastern three-quarters of the north shore. The southern shore generally consists of Cambrian sandstones although there is an area of Beekmantown limestone which runs east from Westport for about 3 kilometers (2 miles).

The soil distribution very closely parallels the bedrock distribution. Tennyson sandy loam which has good drainage and a stoney, slightly calcareous nature, is found in the same areas on the lake as the Beekmantown limestone bedrock. Similarly, Farmington loam which is a shallow, well-drained, stone free soil, is found on the Cambrian sandstone bedrock. The portion of the north shore with the crystalline limestone bedrock is overlain with Tweed sandy loam - rock soil complex. This soil complex is a combination of shallow, well-drained sandy loam with numerous outcrops of rock. The remainder of the north shore is mainly granite and syenite rock outcrop with a few small pockets of shallow soil. In most instances, the soil cover is less than the 1.5 meters (5 feet) required by the Ministry of the Environment for the installation of standard, subsurface septic tank systems.

The shoreline is generally flat to rolling and irregular and about one-half covered with a forest consisting of white birch, spruce and cedar covering about one-half of the shore. The slope of the lake bottom is generally gentle and is composed mainly of sand and gravel.

Climate Range

The Upper Rideau Lake area has a mean annual temperature of 6°C (43°F) and a mean annual precipitation of 86 centimeters (34 inches) including 203 centimeters (80 inches) of snow. The January and July mean daily temperatures are -9°C (16°F) and 20°C (68°F) respectively. According to meteorological reports, the area enjoys over 200 days with no measurable precipitation. The summer climate is conducive to most recreational activities and the winter with its abundance of snow provides for participation in most winter sports.

Water Movement

The Upper Rideau Lake drainage basin, not including the area upstream of Westport Pond, is approximately 66 square kilometers (25 square miles) in area. Upper Rideau Lake is the summit lake (the navigable lake with the highest elevation) of the Rideau Canal System. The water from the lake flows into two different terminal drainage basins and the rate of flow is regulated by two lock systems.

One of the two outlets from the lake is at the Narrows Lock with water passing over the weir adjacent to the lock and entering Rideau Lake and the Ottawa River Terminal Drainage Basin via the Rideau River system. The other outlet is located at the locks in McNallys Bay with the water flowing into Newboro Lake and the St. Lawrence River Terminal Drainage Basin via the Cataraqui River system. The only permanent inlet is near Westport which draws water from Westport (Sand) Lake and Wolfe Lake. This inflow is controlled

by a dam which is operated by the Federal Ministry of Transport. Water level fluctuation is minimized by regulation of the inflow and outflow.

Shoreline Development

Lying between the cities of Kingston and Ottawa and in the heart of the Rideau Canal tourist region, Upper Rideau Lake has a well-developed shoreline. The approximately 240 cottages are generally well-distributed around the entire shoreline (Figure 1).

The Village of Westport with a population of approximately 600, is located at the western end of the lake.

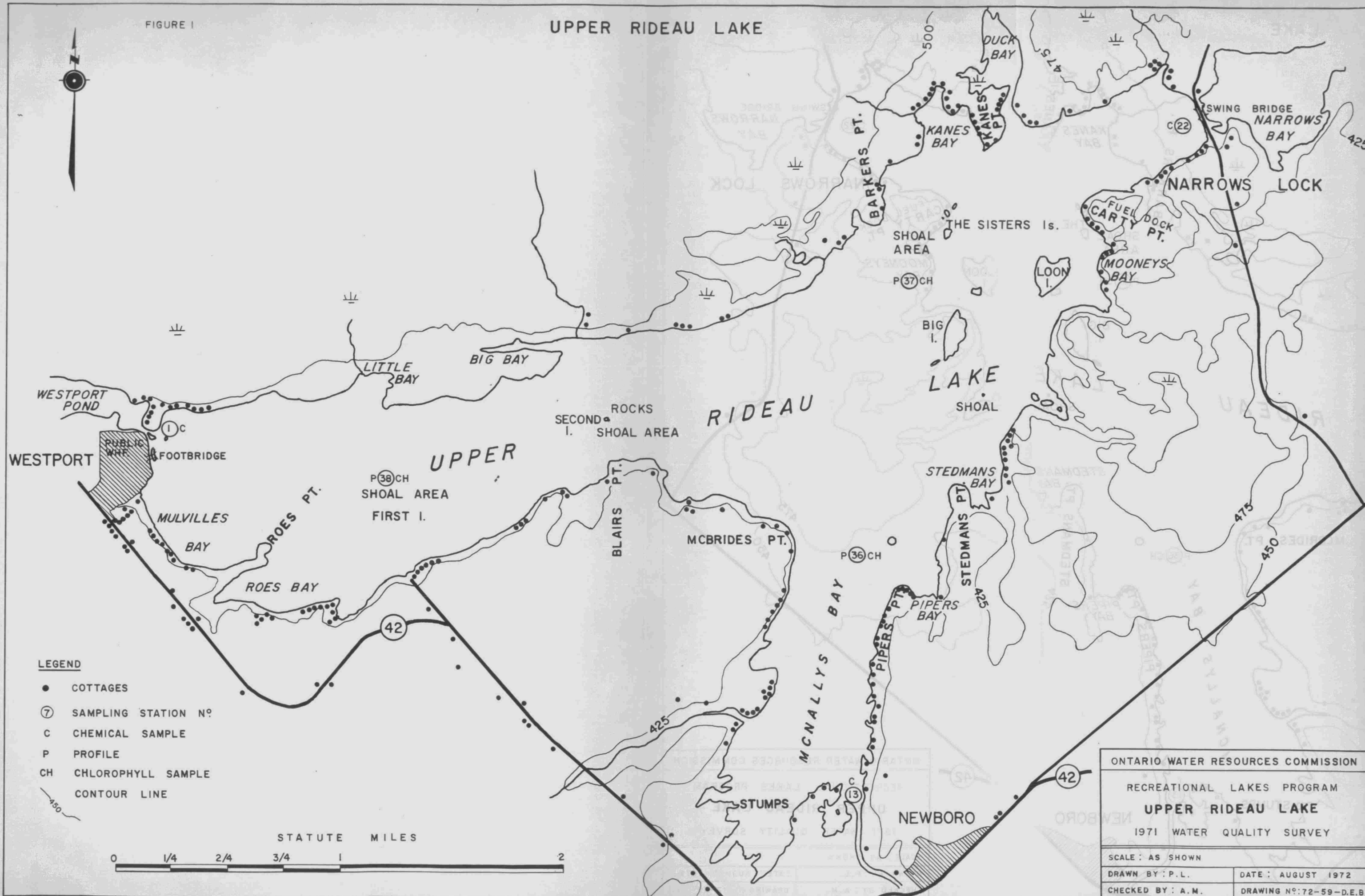
Water Usage

The majority of the cottage owners use the lake water as their source of domestic supply. The lake supports recreational water sports such as fishing, boating, water skiing and swimming. According to the information available from the Ministry of Natural Resources the most common game fish in the lake are northern pike, walleye, largemouth and smallmouth bass.

The Village of Westport is presently using individual private water supplies and subsurface waste disposal systems. However, the village is proceeding with the development of municipal water and sewage works. A waste stabilization pond will be constructed in early 1973 and will be operated on a seasonal retention basis with discharge via a small creek to Upper Rideau Lake. By the end of 1973 phosphorus removal facilities will be incorporated with the waste stabilization pond.

FIGURE 1

UPPER RIDEAU LAKE



ONTARIO WATER RESOURCES COMMISSION	
RECREATIONAL LAKES PROGRAM	
UPPER RIDEAU LAKE	
1971 WATER QUALITY SURVEY	
SCALE: AS SHOWN	
DRAWN BY: P.L.	DATE: AUGUST 1972
CHECKED BY: A.M.	DRAWING N°: 72-59-D.E.B

A sanitary landfill site serving the village and the cottagers is located on Lot 14, Concession 16 in North Crosby Township and does not appear to be posing any pollution hazard to the lake.

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

Water quality surveys were conducted on Upper Rideau Lake in the spring, summer and fall. Three near-shore stations (1, 13 and 22), which are adjacent to inlets and outlets, as well as three mid-lake stations (36, 37 and 38) were selected for biological, physical and chemical sampling (Figure 1).

Dissolved oxygen and temperature profiles were determined daily in the field using a combination dissolved oxygen-telethermometer unit. Total alkalinity and free carbon dioxide were measured daily titrimetrically and pH was measured with a portable pH meter. Daily chlorophyll samples were collected in a 32-ounce bottle, at each mid-lake station, utilizing a composite sampler lowered through the euphotic zone (2X Secchi disc) and immediately preserved with 10-15 drops of a 2% MgCO_3 suspension.

At least once per survey, a 32-ounce sample for hardness, alkalinity, chloride, total phosphorus, total Kjeldahl nitrogen, iron and conductivity was collected at all mid-lake stations. As well, at least one sample was collected at the major inlets and outlets. The mid-lake stations were sampled using a composite sampler through the euphotic zone. At inlets and outlets, samples were collected from 1 meter of depth using a Kemmerer sampler.

At each mid-lake station one sample for total phosphorus, total Kjeldahl nitrogen and iron was obtained by means of a Kemmerer sampler from a depth of 1 meter above the bottom on July 23 and October 4.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus concentrations were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths from 600 to 750 μ using a Unicam SP1800 ultra violet spectrophotometer.

The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Five-day intensive bacteriological surveys were completed in May and July and a four-day survey was completed in September on Upper Rideau Lake. Thirty-eight surface samples were taken daily, as well as three depth samples at Stations 30, 37 and 38.

Surface samples were collected at a depth of one meter below the surface using sterile, autoclavable polycarbonate 250 ml bottles. Depth samples were collected one meter above the bottom using a modified "piggy back" sampler and sterile 237 ml evacuated rubber air syringes.

All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration technique (MF) (Standard Methods, 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC), fecal coliforms (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. The "indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing micro-organisms may also be present.

The coliform group is defined, according to Standard Methods, 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden-green metallic sheen within 24 hours of incubation" using the

MP technique. This definition includes, in addition to the intestinal forms of the Escherichia coli group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter - Citrobacter groups are common in soil but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid, gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal materials, fecal streptococci are usually found along with coliform bacteria, but in small numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

Bacteriological Stastical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on the lake can be grouped, by this method, into areas or groups of stations within the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with slight differences in bacterial concentration may be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analysis of variance program (ANOVA-CRE; Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed.

Both of these assumptions were checked on Upper Rideau Lake. The Bartlett's test was found to be non-significant and the data followed a normal distribution, hence the analysis of variance (F-test, Sokal, 1969) was calculated on all stations.

If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the three surveys.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

During the July survey, a well-defined thermocline or zone of rapid temperature decline was observed between 7 and 10m of depth (Figure 2a). This temperature zone serves as a physical barrier to mixing between the warm upper waters (epilimnion) and the cool bottom waters (hypolimnion). Dissolved oxygen concentrations declined rapidly through the thermocline and were as low as 0.7 mg/l in the bottom waters of Station 37. The deep-water oxygen depletion resulted from bacterial oxidation of organic matter, biological respiration and chemical oxidation.

By mid-September, the thermocline was located 4m deeper than during the preceeding survey (Figure 2b). This phenomenon, as well as the cooler surface water temperatures, were in keeping with the expected seasonal changes characteristic of many inland recreational lakes. At Station 37, a rapid dissolved oxygen decline from 10.9 to 0.2 mg/l occurred through the thermocline (ie. between 11 and 14m). From July to mid-September the zone of cool bottom water, located beneath the thermocline, was essentially void of dissolved oxygen and would not be expected to sustain cold-water species of fish such as lake trout, whitefish and herring.

FIGURE 2a

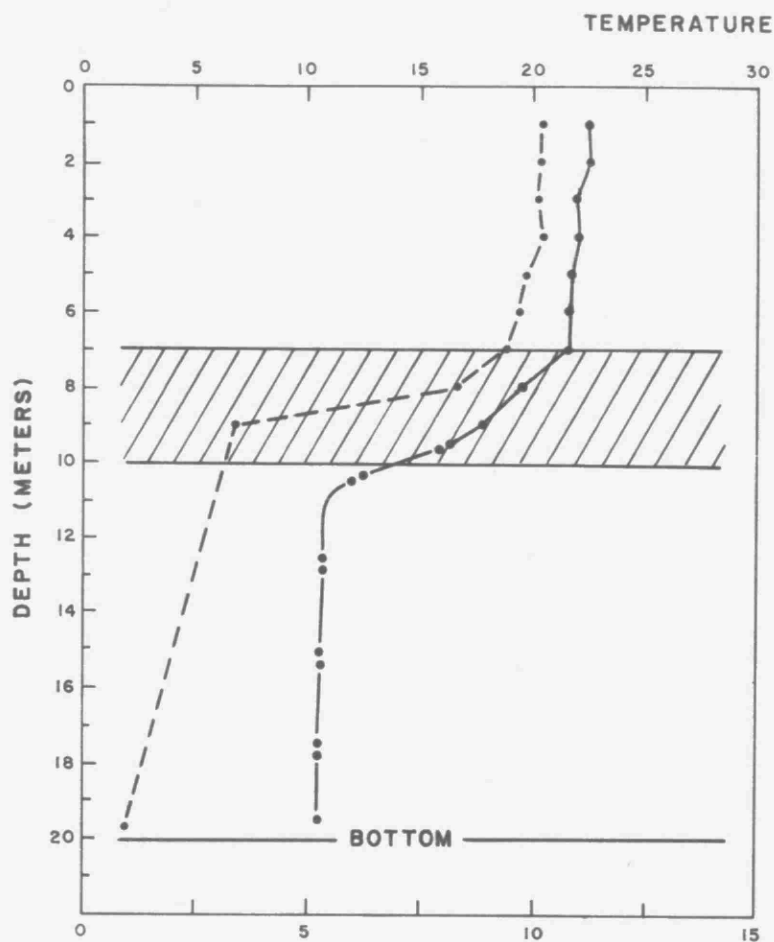


FIGURE 2b

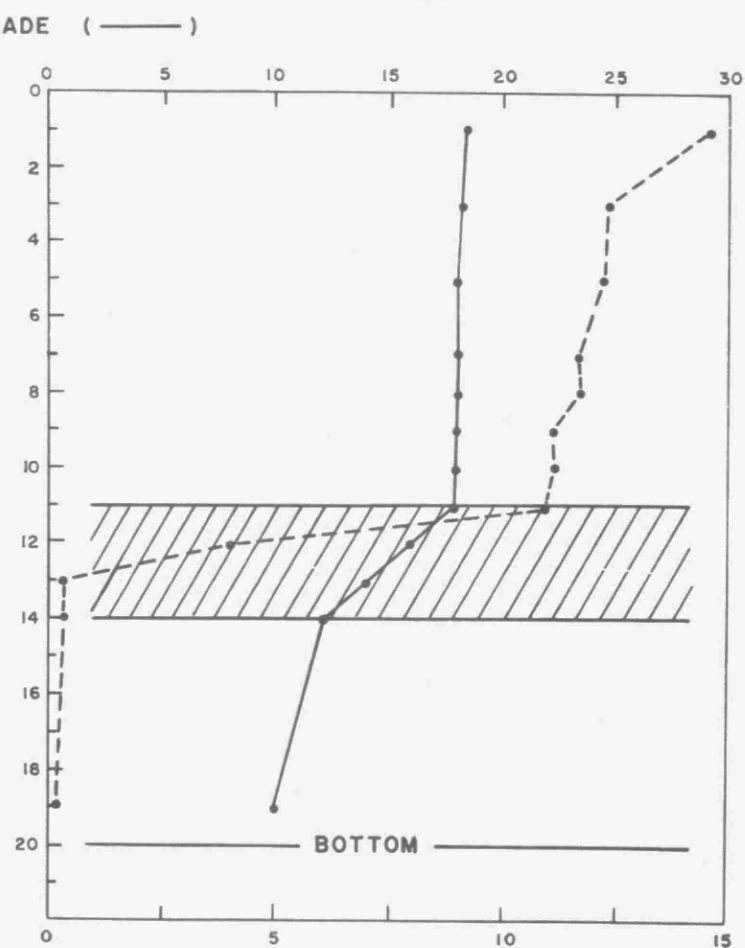


FIGURE 2 : TEMPERATURE AND DISSOLVED OXYGEN PROFILES IN UPPER RIDEAU LAKE , STATION 37(a) FOR JULY 25, 1971 AND (b) FOR SEPTEMBER 26, 1971. THE LINE (—•—) IN FIGURE 2a IS AN APPROXIMATION. THE SHADED AREAS REPRESENT THE POSITION OF THE THERMOCLINE.

pH, Free Carbon Dioxide and Total Alkalinity

Mean surface pH values for the mid-lake stations were 8.4, 8.5 and 8.3 for the May, July and September surveys respectively. Surface pH values were consistently higher than those in the deeper strata. For example, at Station 35, on July 27, values at 1 and 12m were 8.5 and 7.2 respectively.

Surface waters concentrations of free CO_2 were low throughout the year while bottom water values were high under conditions of thermal stratification. Specifically, on September 24 at Station 37, values were 2.4 and 9.3 mg/l at 1 and 18m respectively. These high deep-water carbon dioxide values (as well as the above mentioned lower pH conditions) were related to conditions of organic decomposition.

The moderately hard water nature of the lake was indicated by the relatively high values for total alkalinity. In general, surface values varied by 3 mg/l or less, and concentrations were slightly higher in the bottom waters than in the surface strata. For example, values at 1 and 16m on July 24 (Station 37) were 98 and 106 mg/l respectively. The higher alkalinity values in the bottom waters relative to surface conditions indicate that release of bicarbonate from sediments was occurring through bacterial and chemical action in conjunction with calcium, magnesium, iron, manganese and ammonia.

Hardness, Chloride, Conductivity and Iron

The hardness, chloride and conductivity data (Table 1) were consistent with each other indicating that no unusual mineral characteristics were present. The hardness is such that the use of detergents containing phosphorus is desirable for washing purposes. If such detergents are used

by cottagers, every effort should be made to ensure that the waste disposal systems do not allow any phosphorus to gain access to the lake.

The iron concentrations (Table 1) were uniformly low with one exception, the bottom water at Station 37 on July 23. This single high concentration may have been due to recycling from the sediments.

Kjeldahl Nitrogen and Total Phosphorus

The surface water concentrations of Kjeldahl nitrogen and total phosphorus (Table 1) were relatively high and could be expected to support nuisance levels of algal growth.

There were particularly high concentrations of both Kjeldahl nitrogen and total phosphorus in the bottom waters at Stations 36 and 37 on July 23. The corresponding low dissolved oxygen level and elevated iron concentration at Station 36 suggests that there was some recycling from the sediments. As the lake cools to a uniform temperature in the fall and is fully or even partially mixed by wind action, these nutrients will become available to algae in the surface waters and may augment algal growth. It is likely that this mechanism was partly responsible for the high chlorophyll a concentrations observed during the September survey since approximately 4m of nutrient rich bottom water had been mixed with the surface water by this time.

Chlorophyll a

The algal levels in the Upper Rideau Lake, as reflected by chlorophyll a concentrations were low during May, June and July. Moderately high values developed in August while nuisance concentrations were present during September (Table 2). Such high values would be expected to reduce severely water-oriented recreational activities such as swimming and water skiing and diminish the aesthetic quality of the lake.

As indicated above, chlorophyll a measures the amount of photosynthetic green pigment in algae while water clarity which is one of the more important parameters used in defining water quality is determined using a Secchi disc. Recently, Brown (1972) has indicated that a near-hyperbolic relationship exists between chlorophyll a concentrations and Secchi disc readings for lakes of Precambrian origin. Figure 3 describes the author's mathematical relationship between chlorophyll a and Secchi disc for 945 sets of data collected from approximately sixty recreational lakes located primarily in Southern Ontario. Eutrophic lakes which are characterized by high chlorophyll a concentrations and poor water clarity have values situated along the vertical axis of the hyperbola while oligotrophic waters which have low chlorophyll a levels and allow significant light penetration lie along the horizontal limb. Data for mesotrophic lakes would be dispersed about the middle section of the curve. The enriched or eutrophic status of Upper Rideau Lake is revealed by its position midway between values computed for the Bay of Quinte, the Western Basin of Lake Erie and Gravenhurst Bay - three highly enriched bodies of water, and the oligotrophic to mesotrophic Lake Ontario and Eastern Basin of Lake Erie.

FIGURE 3

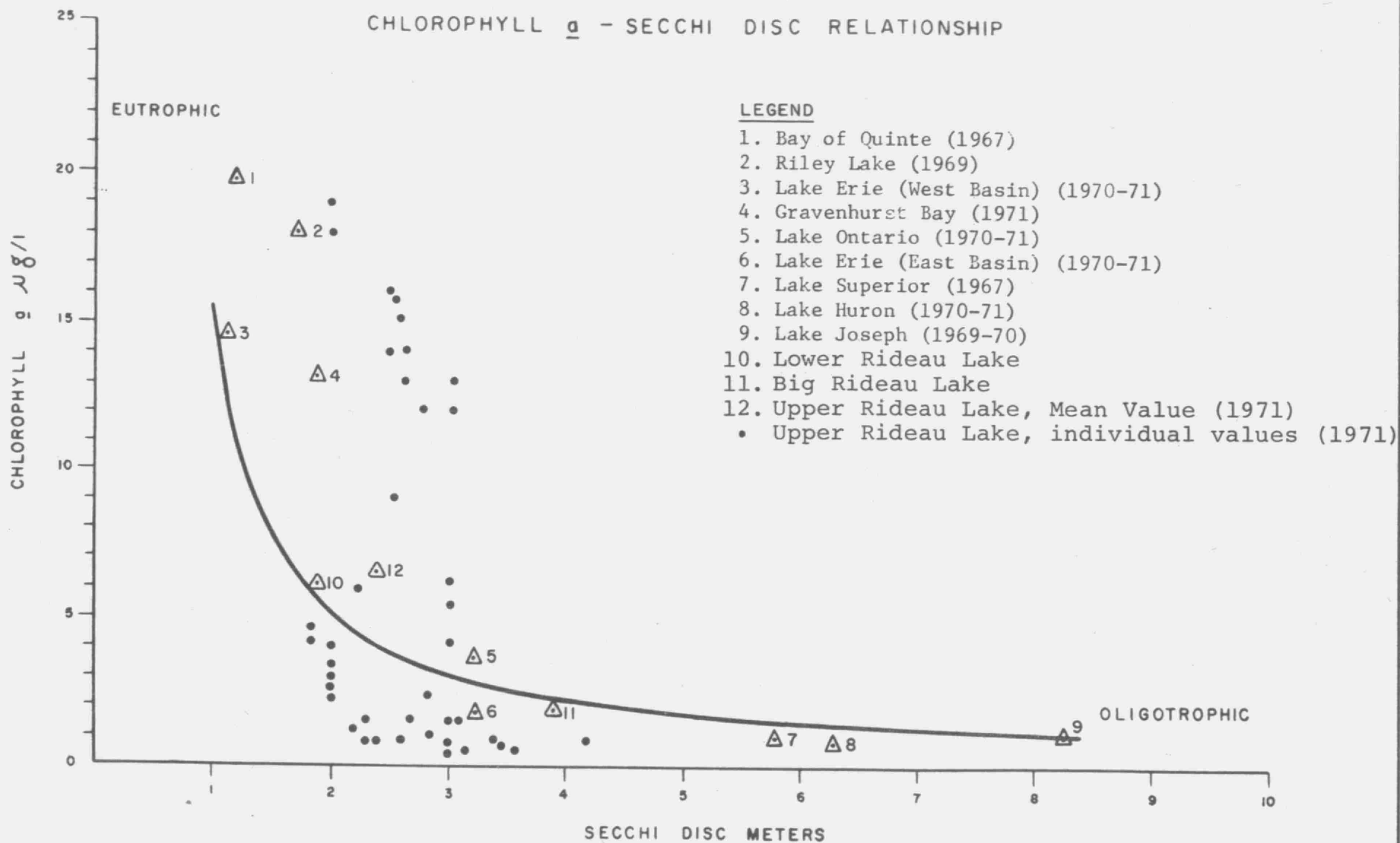


Figure 3: The relationship between chlorophyll a and Secchi disc as determined from the recreational lakes surveyed in 1971 as well as the individual and overall mean values of chlorophyll a Secchi disc for Upper Rideau Lake. The values for the Great Lakes were added for comparative purposes.

Bacteriology

Upper Rideau Lake was generally well within the OWRC criteria for total body contact recreational use (OWRC, 1970) during all three surveys.

During the May survey, the overall geometric mean bacterial levels for most of the lake (Group A) were 36 TC/100 ml, 1 FC/100 ml and 6 FS/100 ml (Figure 4, Tables 3, 4, and 5). Group B, which included the central part of the lake had a significantly lower TC mean of 3/100 ml and Group C along the eastern half of the north shore had a lower FS mean of 1/100 ml. Stations 2, 13 and 34 with 3 FC/100 ml, 7 FC/100 ml and 9 FS/100 ml respectively were higher than Group A, while Stations 35 with 1 FS/100 ml and Station 36D with 3 TC/100 ml were significantly lower.

During the July survey the overall geometric mean bacterial levels for Group A were 30 TC/100 ml, 2 FC/100 ml and 4 FS/100 ml. McNally's Bay (Stations 11, 12, 13 and 14) with 165 TC/100 ml was higher than Group A (Figure 5). The rainfall on July 24 (0.13 inches were recorded at Hartington) and the associated runoff caused an increase in the bacterial concentrations on July 25 and 26. The greatest increases were observed around Westport and in the McNally Bay area. Fecal coliform concentrations jumped from 1/100 ml on July 24 at Station 1 to 206/100 ml on July 26. At Station 11, FC concentrations increased from 1/100 ml on July 24 to 800/100 ml on July 25. These high FC densities may be indicative of a short term health hazard after a rainfall.

FIGURE 4 MAY SURVEY

UPPER RIDEAU LAKE

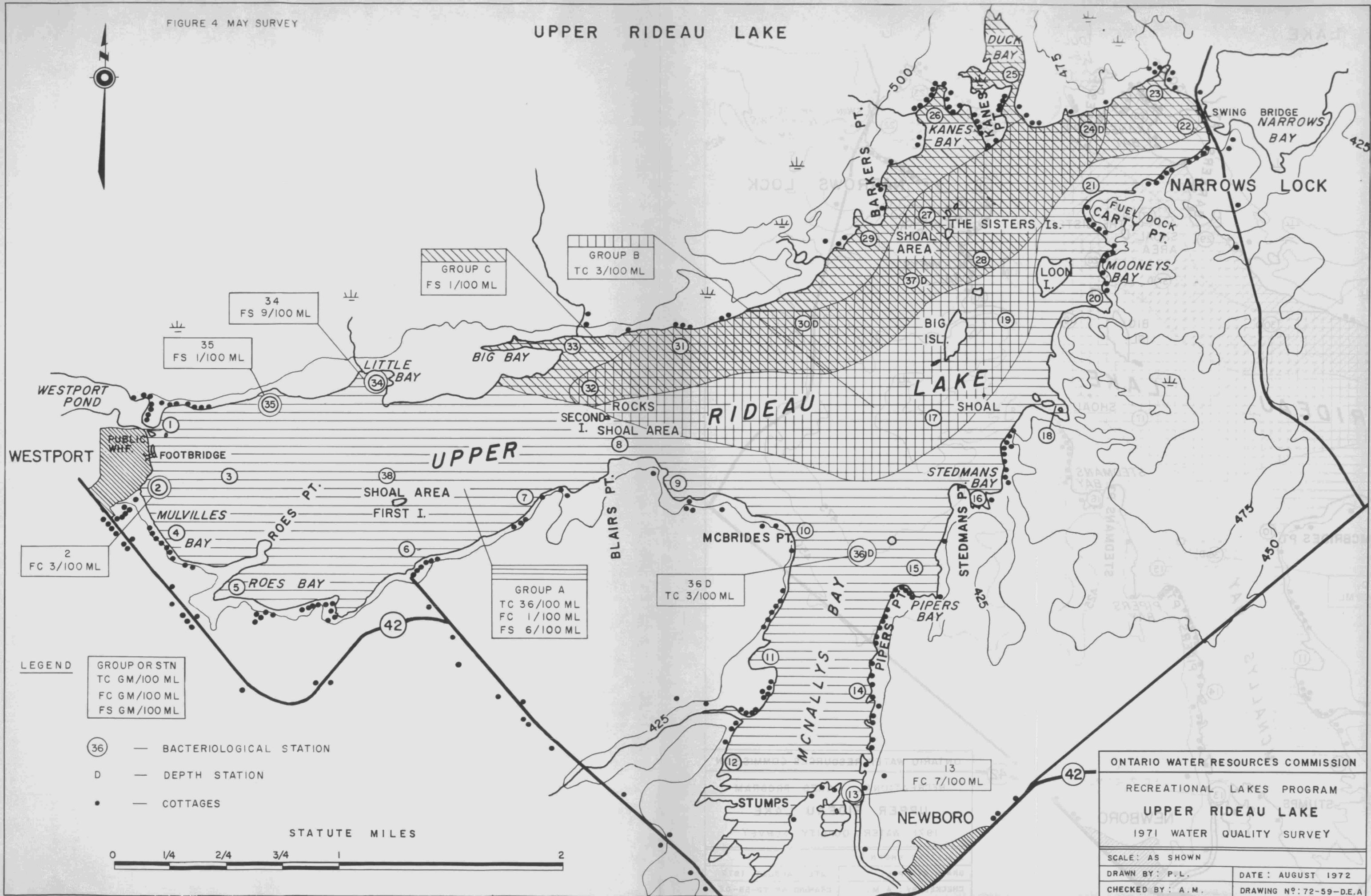
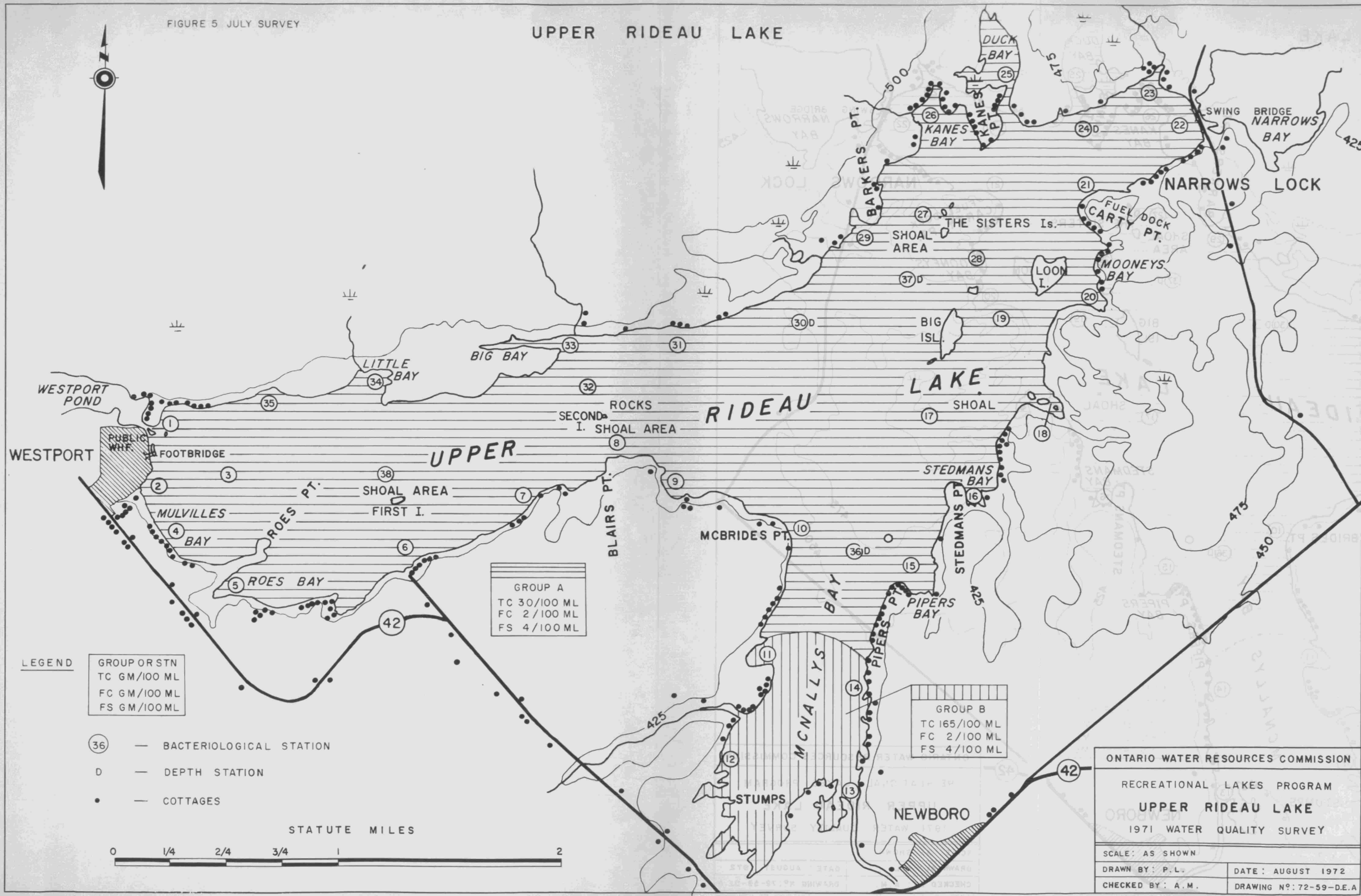


FIGURE 5 JULY SURVEY

UPPER RIDEAU LAKE



ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM

UPPER RIDEAU LAKE

1971 WATER QUALITY SURVEY

SCALE: AS SHOWN

DRAWN BY: P.L. DATE: AUGUST 1972

CHECKED BY: A.M. DRAWING NO: 72-59-D.E.A

During the September survey the entire lake was bacteriologically homogeneous with overall geometric mean levels of 3 TC/100 ml, 1 FC/100 ml and 1 FS/100 ml.

Although Upper Rideau Lake was well within the OWRC recreational use criteria, no surface water is considered potable without prior treatment including disinfection.

FIGURE 6 SEPTEMBER SURVEY

UPPER RIDEAU LAKE

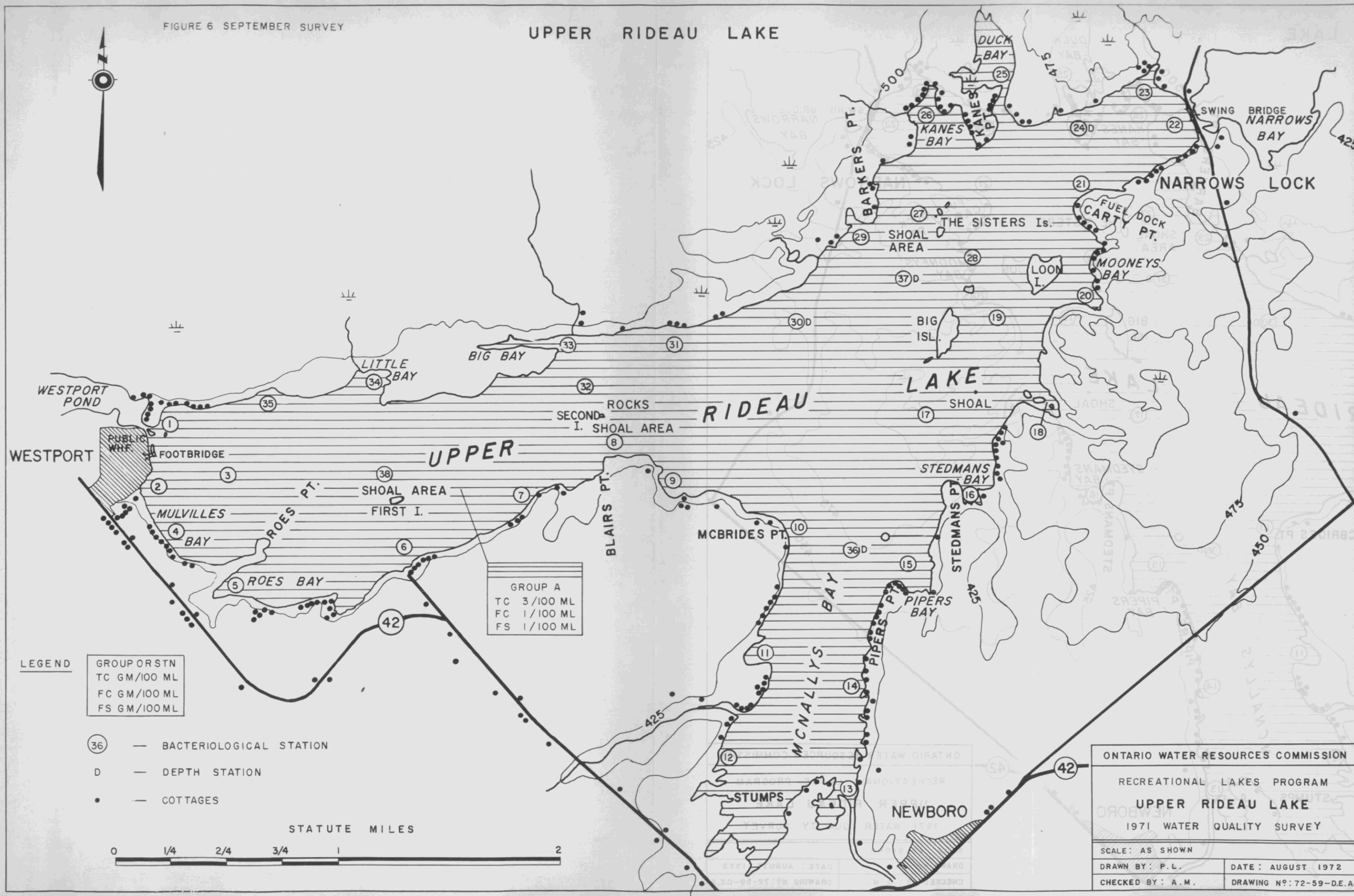


TABLE 1

Iron, Hardness (Hard), Total Phosphorus (P), Total Kjeldahl Nitrogen (N), Chloride (Cl) and Conductivity (Cond) for Upper Rideau Lake, 1971.
Results are expressed in mg/l except conductivity which is umhos/cm³.

Station	Depth	Date	Iron	Hard.	P	N	Cl	Cond.
1	1m	23/7	0.05L	106	0.023	0.49	11	212
13	1m	23/7	0.10	108	0.040	0.56	12	218
13	1m	27/9	0.05	106	0.030	0.55	6	211
22	1m	23/7	0.05	108	0.022	0.51	12	220
22	1m	27/9	0.05	106	0.026	0.53	6	219
36	1m	28/5	0.10	104	0.032	0.54	7	225
36	1m	30/5	0.05	106	0.030	0.19	6	-
36	1m comp	1/6	0.10	106	0.042	0.65	8	-
36	6.2m comp	23/7	0.05	108	0.028	0.56	12	220
36	13m	23/7	0.30	-	0.092	0.96	-	-
36	5m comp	27/9	0.05	106	0.028	0.53	6	219
36	6m comp	4/10	0.05	106	0.030	0.56	6	221
36	11m	4/10	0.10	-	0.048	0.58	-	-
37	1m	28/5	0.05	104	0.052	0.70	5	226
37	4.8m comp	30/5	0.05	106	0.016	0.52	6	-
37	4m	1/6	0.05	106	0.026	0.59	6	-
37	6m comp	23/7	0.05	108	0.024	0.51	11	220
37	19.5m	23/7	0.10	-	0.11	0.90	-	-
37	5m comp	27/9	0.05	106	0.038	0.62	7	219
37	6m comp	4/10	0.05	106	0.032	0.57	6	220
37	15m	4/10	0.05	-	0.030	0.54	-	-
38	4m comp	28/5	0.10	104	0.029	0.52	5	220
38	4m comp	30/5	0.05	106	0.039	0.70	6	-
38	4m comp	1/6	0.05	106	0.028	0.44	6	-
38	4.4m comp	23/7	0.05	108	0.030	0.62	13	221
38	6.5m	23/7	0.05	-	0.022	0.62	-	-
38	4m comp	27/9	0.05	106	0.032	0.60	6	217
38	4m comp	4/10	0.05	106	0.034	0.70	6	221
38	5m	4/10	0.05	-	0.030	0.58	-	-

= Less Than

"Comp" means a composite sample taken through the depth indicated.

TABLE 2.

Chlorophyll a and Secchi disc values for Upper Rideau Lake, Stations 36, 37 and 38 during 1971.

DATE	CHLOR.a	S.D.	CHLOR.a	S.D.	CHLOR.a	S.D.
May 30	2.5 ug/l	2.8 m	0.8 ug/l	2.4 m	- ug/l	- m
June 1	2.6	2.0	3.0	2.0	2.3	2.0
June 3	4.1	1.8	4.5	1.8	3.3	2.0
July 23	1.5	3.1	1.4	3.0	1.6	2.3
July 24	0.9	2.6	0.5	3.1	1.3	2.2
July 25	0.8	4.2	0.9	3.4	1.6	2.7
July 26	0.8	3.4	0.3	3.0	1.0	2.9
July 27	0.8	3.0	0.6	3.5	0.8	2.3
August 14	6.1	2.3	-	-	-	-
August 15	5.3	3.0	-	-	-	-
September 24	12.0	3.0	8.6	2.5	13.0	2.5
September 25	13.0	3.0	12.0	2.6	16.0	2.5
September 26	15.0	2.6	14.0	2.5	19.0	2.0
September 27	14.0	2.5	16.0	2.5	18.0	2.0
October 4	6.3	3.0	4.1	3.0	4.0	2.0
Mean	5.71	2.82	5.13	2.72	6.83	2.28

Overall mean Chlorophyll a 5.86 ug/l
 Secchi Disc 2.63 m

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

- F - the calculated analysis of variance statistic on F ratio.
- df - degrees of freedom of the F ratio for "between group" and "within group" variation.
- F(5%) - the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.
- log GM - the logarithm (base 10) of the geometric mean.
- S.E. - the standard error of the log GM where

$$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$$

- N - the number of values in the mean.
- GM - the geometric mean of the bacterial level.
- t - the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD** refers to a significant difference at the .001 level.

TABLE 3

UPPER RIDEAU LAKE

ANALYSIS OF VARIANCE SUMMARY OF GROUPS

PARAMETER - TOTAL COLIFORM

SURVEY	May 28-June 1	July 23-27	Sept. 24-27
GROUP RUN 1	ALL STATIONS	ALL STATIONS	ALL STATIONS
F	2.954	1.611	0.507
df	41,143	40,160	41,124
F5%	1.488	1.485	1.499
	-NSD	-SD	-NSD
GROUP	Group A (St.17, 19,24,D24,27,28, 30,31,32,37,037)	Group A (all stations ex- cept 11-14)	ALL STATIONS
F	0.573	1.131	0.507
df	12,46	35,140	41,124
F5%	1.976	1.519	1.499
	-NSD	-NSD	-NSD
log G.M.	0.4278	1.4819	0.4921
S.E.	0.0733	0.0546	0.0590
N	59	176	166
G.M.	3	30	3

TABLE 3 (cont'd)

TOTAL COLIFORM	MAY	JULY	SEPTEMBER
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GROUP	Group B (St.1-16,18,20-23 25,26,29,33-35)	Group B (St.11-14)	
F	1.196	0.2708	
df	25,85	3,16	
F5%	1.640	3.24	
log G.M.	1.5546	2.2174	
S.E.	0.0889	0.1453	
N	111	20	
G.M.	36	165	

TABLE 4

UPPER RIDEAU LAKE

ANALYSIS OF VARIANCE SUMMARY OF GROUPS

PARAMETER - FECAL COLIFORM

SURVEY	May 28-June 1	July 23-27	Sept. 24-27
GROUP RUN 1	ALL STATIONS	ALL STATIONS	ALL STATIONS
F	2.125	0.819	0.877
df	41,162	40,161	41,122
F5%	1.480	1.485	1.501
	-SD	-NSD	-NSD

GROUP	Group A (all stations except 2,13)	ALL STATIONS	ALL STATIONS
F	0.895	0.819	0.877
df	39,154	40,161	41,122
F5%	1.492	1.485	1.501
	-NSD	-NSD	-NSD
log G.M.	0.0431	0.1664	0.0923
S.E.	0.0160	0.0297	0.0284
N	194	202	164
G.M.	1	2	1

TABLE 5

UPPER RIDEAU LAKE

ANALYSIS OF VARIANCE SUMMARY OF GROUPS

PARAMETER - FECAL STREPTOCOCCUS

SURVEY	May 28-June 1	July 23-27	Sept. 24-27
GROUP RUN 1	ALL STATIONS	ALL STATIONS	ALL STATIONS
F	2.455	1.059	1.400
df	41,144	40,155	41,122
F5%	1.488	1.487	1.501
	-SD	-NSD	-NSD

GROUP	Group A (St.22-33,35- 38 D24,D30,D36, D37)	ALL STATIONS	ALL STATIONS
F	0.821	1.059	1.400
df	18,70	40,155	41,122
F5%	1.757	1.487	1.501
	-NSD	-NSD	-NSD
log G.M.	0.1331	0.6344	0.0867
S.E.	0.0347	0.0461	0.0215
N	89	196	164
G.M.	1	4	1

TABLE 5 (cont'd)

UPPER RIDEAU LAKE

FECAL STREPTOCOCCUS

GROUP	Group B (St. 1-21,36)
F	1,000
df	21,70
F5%	1.711
	-NSD
log G.M.	0.7492
S.E.	0.0717
N	92
G.M.	6

GLOSSARY OF TERMS

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL <u>a</u>	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESOTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

SECCHI DISC

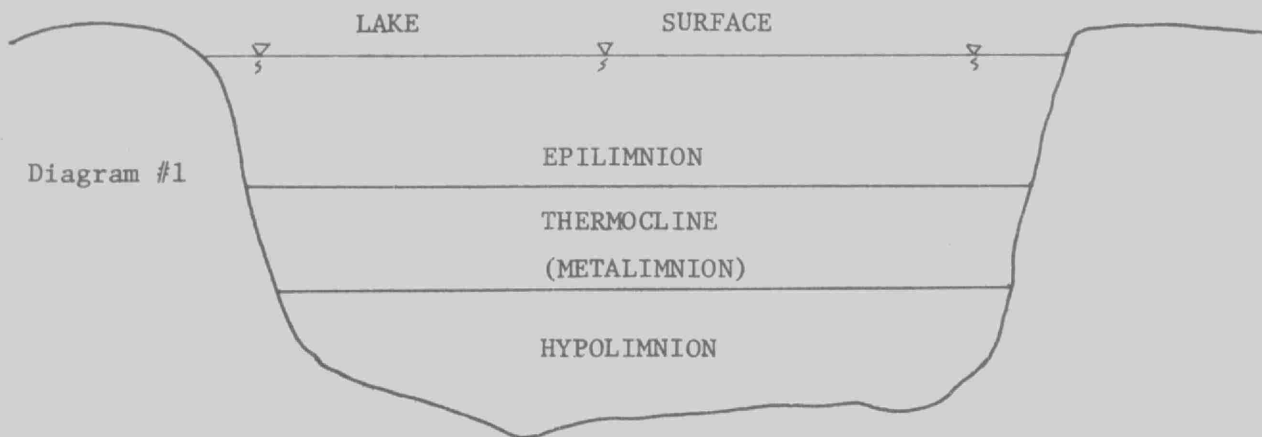
:A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION

:During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

THERMOCLINE (metalimnion)

:The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding 1°C increase per meter.



TOTAL COLIFORMS (TC)

:Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS

:Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS
(continued)

:oligotrophic, mesotrophic and eutrophic.

If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

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Microbiological Criteria

Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds 1,000, 100 and/or 20 per 100 ml respectively, in a series of at least 10 samples per month, including samples collected during weekend periods.

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